ESA MODEL 75A
ELECTROMETER

EAI

ELECTRONIC ASSOCIATES INC. ■ SCIENTIFIC INSTRUMENTS DIVISION
PALO ALTO, CALIFORNIA

ESA MODEL 75A

ELECTROMETER

I. INTRODUCTION

The ESA 75A Electrometer is a solid state electrometer amplifier capable of measuring currents ranging from 10^{-4} to 10^{-12} amps D.C. Range can be extended to 10^{-14} amps on special request.

The amplifier is designed to mount directly on EAI Quadrupole mounting flanges with direct electrical connection to the signal output connector. Thermal isolation and rigid mechanical coupling are maintained for minimum effects due to thermal and vibration causes. No Quadrupole assembly modifications are required for mounting.

The ESA 75A has three simple operator controls mounted on the top and side of the amplifier housing: (a) an "OFF-ON" switch on the side, (b) a gain selector switch for 4 linear and one LOG position and (c) a noise filter switch (5 position). Three additional screwdriver adjustments are located on the side for use during calibration.

The amplifier is capable of driving all types of recorders, oscilloscopes, and other operating devices whose combined input impedance is more than 5000 ohms.

2. GENERAL DESCRIPTION

2.1 General:

2.1.1 The ESA 75A Electrometer is a compact, single-ended current-in/voltage-out amplifier of the non-inverting type. The ESA 75A has four step gain positions. The gain is selected by an external range selector switch.

2.1.2 The four linear ranges of the electrometer will produce an output of 10 volts D.C., full scale, for any input currents of 10^{-5} to 10^{-8} amps. A fifth range provides a logarithmic scale.

2.1.3 Normal open loop D.C. voltage gain is approximately 10^{5}.

2.2 Features:

2.2.1 A $\pm$ 15 volt power supply is designed and incorporated in the same chassis.

2.2.2 A five position active filter is incorporated in the amplifier for smoothing mass peaks.

2.2.3 The input is protected against an accidental overload.

2.2.4 Special fast overload recovery circuits have been incorporated to minimize amplifier saturation during excessive input currents. This assures normal output immediately following a 10 times full scale input.

2.2.5 Input impedance is dependent on the gain selected.

Open loop impedance is 10^{-14} ohms or greater.

2.3 Specifications

2.3.1 Signal In

The ESA 75A amplifier accepts positive or negative input current in four linear ranges and one logarithmic range. The current-in/voltage-out relationship is shown below:

Switch Position	Input Current	Output Voltage
D	10^{-8} Amps	10 MV
	10^{-7} Amps	100 MV
	10^{-6} Amps	1 Volt
	10^{-5} Amps	10 Volts
C	10^{-9} Amps	10 MV
	10^{-8} Amps	100 MV
	10^{-7} Amps	1 Volt
	10^{-6} Amps	10 Volts
B	10^{-10} Amps	10 MV
	10^{-9} Amps	100 MV
	10^{-8} Amps	1 Volt
	10^{-7} Amps	10 Volts
A	10^{-11} Amps	10 MV
	10^{-10} Amps	100 MV
	10^{-9} Amps	1 Volt
	10^{-8} Amps	10 Volts

Switch Position	Input Current	*Output Voltage
Log	10^{-12} Amps	0 Volts
	10^{-11} Amps	1.25 Volts
	10^{-10} Amps	2.50 Volts
	10^{-9} Amps	3.75 Volts
	10^{-8} Amps	5.00 Volts
	10^{-7} Amps	6.25 Volts

Switch Position	Input Current	*Output Voltage
Log	10-6 Amps	7.50 Volts
	10-5 Amps	8.75 Volts
	10-4 Amps	10.00 Volts

* These readings are ideal and they will vary from unit to unit due to the characteristics of the logarithmic element. The amplifier is calibrated for maximum linearity around the center four decades.

2.3.2 Output voltage (with greater than 5 K ohm load):

a. Linear: -10 volts for full scale negative input current

+10 volts for full scale positive input current

b. Logarithmic: -1.25 volts per decade of negative input currents

2.3.3 Gain with Standard Ranges:

Switch Position	Feedback Resistance Megohms	Full Scale Input Current Amps	Full Scale Output Voltage Volts
A	1000	10^{-8}	10
B	100	10^{-7}	10
C	10	10^{-6}	10
D	1	10^{-5}	10

2.3.4 Accuracy:

a. D.C. accuracy of linear ranges is within 0.1% of full scale up to $\pm$ 10 volts output

b. Logarithmic conformity within 10% for each decade of

input current over the range of from 10^{-11} amps to 10^{-4}.

2.3.5 Dynamic Range, Linear Ranges:

1.millivolt (basic resolution) to 10 volts output (4 decades). 1 millivolt on 10^{-8} amp range corresponds to 10^{-12} amps input current. Range can be extended to 10^{-14} amps when specifically requested.

2.3.6 Noise, Wide Band:

The basic noise level of the electrometer is equivalent to 10^{-13} amps. The noise is less than 1 millivolt peak-to-peak on all linear ranges when unit is mounted directly on system. There is less than 5 millivolts peak-to-peak of noise with 5 feet of cable on input.

2.3.7 Input Power Required:

Input -- 90 - 140 volts rms, 60 Hz

Power -- 3 watts maximum

2.3.8 Dimension:

2.16" high x 3.72" wide x 5.72" deep

3. OPERATIONAL INSTRUCTIONS

3.1 Controls and Terminals

a. Range Switch S1 -- The range switch S1 selects one of the five ranges: A, B, C, D, and log. Ranges marked A, B, C, and D switches in gain factors of 1,000, 100, 10 and 1 respectively. Range marked "Log" switches in the log scale.

b. Switch S3 -- Switch S3 selects capacitors of .05μf, .01 μf, .005 μf, and .001 μf to provide active filtering.

c. Input-Jack -- J1

d. Output -Jack -- J2

e. Power Input-Plug -- P1 is the 117 AC power input.

f. Zero Adjust Pot -- Trimpot (R-24) provides the zero offset calibration adjustment for the linear ranges.

g. Gain Adjust Pot -- Trimpot (R-12) provides the gain adjustment for the logarithmic range.

h. Bias Adjust Pot -- Trimpot (R-19) provides a bias adjustment for the log scale range.

3.2 Calibration Procedure

a. Place the power supply switch S2 to OFF position.

b. Connect 117 AC to the electrometer through plug P1.

c. Connect a BNC Dust Cover (Non-shorting type) to the electrometer input jack J1.

d. Connect the output jack J2 to an oscilloscope or recording device.

e. Place the range switch position to D.

f. Turn switch S2 to ON position.

g. Set S3 active filter switch in Min. position.

3.3 Procedure (Operating)

a. Zero Adjust

1) With the input to the electrometer capped with a shielded dummy BNC connector, monitor the out put on the oscilloscope. Adjust the linear output to zero $\pm$ 1 mv by adjusting zero adjust trimpot R24. Check for zero output on ranges C, B, and A.

b. Log Scale

1) Gain and Bias Adjust

a) Turn the range switch to LOG position.

b) Remove the input shield.

c) Using a picoamp source for input, adjust bias pot R19 for an output of 5V $\pm$ 1 mv with 10^{-8} amps input. Adjust the gain pot R12 to achieve a difference of 1.25 per decade over the range from 10^{-8} to 10^{-6} amps.

d) Check entire range from 10^{-12} to 10^{-4} amperes input. Input of 10^{-12} A should be zero output but may have some offset due to the linearity of the logarithmic element.

e) Since both gain and zero adjustment interact, repeat gain and bias adjust until step D is satisfied.

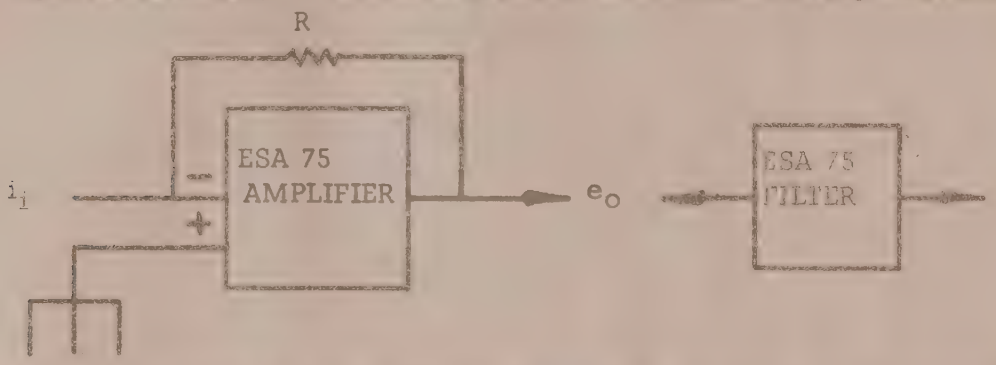
f) Turn the range switch S1 to D position.

g) Select switch S3 for the amount of filter action required on the output signal.

h) The electrometer is ready for operation.

4. CIRCUIT DESCRIPTION

The input stage consists of a differential J-FET, Q1, which provides high input resistance (10^{14} ohms or greater) to the signal being measured.



The input current (i_i) of 10^{-6} amps fed to the summing junction of the high gain amplifier, with a feedback resistor of 10^{7} ohms, will produce a 10 volt D.C. output.

The output of the differential J-FET, Q1, provides input to amplifier A1. Amplifier A2 is used as an inverter (gain of 1) and active filter component and also provides the low impedance output signal for driving external devices.

Frequency compensation of Amplifier A1 is obtained by capacitor C2. In amplifier A2 frequency compensation is determined by C10 and R17 at the input and C11 and R18 at the output.

High frequency noise is minimized by the active filter which includes capacitors C3, C5, C7 and C8 across the feedback resistor R14 of amplifier A2. Any one of the capacitors can be chosen by switch S3 for optimum signal to noise ratio.

Resistors R1, R2, R3 and R4 are the feedback resistors between the output of amplifier A1 and the signal input and they determine the gain of the electrometer. Range switch S1 selects one of these resistors. Transistor Q4 provides the diode log function in the log scale range.

Bias adjust trimpot R19 in conjunction with CR4 provides DC bias in the log scale range. The input to the J-FET is protected for any source voltage by Q6 and Q7 which are used as back-to-back diodes with zener action at ± 6 volts.

4.1 Power Supply

4.1.1 General Description

a. The DC power requirements for the reference voltages and amplifiers A1 and A2 are supplied by the self-contained power supply section located in the lower half of the amplifier.

4.1.2 Specifications

Output -- Voltage: ± 15 VDC

Current: ± 10 ma

Input -- 117 V AC at 60 Hz

Line voltage regulation -- Less than 0.1% change in output voltage for a change of ± 25 volts AC line voltage at 60 Hz.

Drift due to temperature -- Less than 1 mv/°C

Output Ripple -- Less than 1 mv P-P

4.1.3 Circuit Description

117 AC line voltage is stepped down to approximately 50 volts AC by transformer T1. Full wave rectifier bridge CR5 converts the 50 volts AC to 25 VDC. Filtering is provided by R27, R28, C12 and C13 on +15 volts line and R29, R30, C14 and C15 on the -15 volts DC line. Zener regulation is provided by CR1 for +15 volts DC and by CR2 for -15 volts DC.

5. MAINTENANCE

The following may be used as a guide to [illegible] the unit fails to operate properly.

	Symptom	Probable Defective Component	Action
1.	Unable to zero on any Linear range	A1 or A2	Check by Replacing
	Unable to zero on any Linear range	J-FET Q-1	Check by Replacing
	Unable to zero on any Linear range	R-24	Check For Proper Resistance Replace if Necessary.
2.	Unable to zero on some but not all Linear ranges	Broken Feedback Resistor Lead	Repair or Replace
	Unable to zero on some but not all Linear ranges	Defective Feedback Resistor	Repair or Replace
3.	Unable to get Correct Readings on log scale	J-FET Q-1	[illegible]
	Unable to get Correct Readings on log scale	A1 or A2	Replace
	Unable to get Correct Readings on log scale	Q-4	Check with Transistor Checker
	Unable to get Correct Readings on log scale	Pot. R-12 or R-19	[illegible]

EAI—PARTS LIST

PARTS LIST NO.	TITLE
A04.01073 PL SHEET 1 OF	ESA MODEL 75 ELECTROMETER
L D NO LD04.01074	

PROJ NO	ENGINEER	DATE	APPROVED	DATE
5822	G. R. Aamoth	12-28-67		

REV	E O NO	DATE	APP'D
1	Orig.Issue	7-10-67	
2	REVISED	12-28-67	
3	00483	3-20-68	
4	00489	4-15-68	
5	00560	12-20-68	

REF DESIG	PART NO AND MANUFACTURER	DESCRIPTION			
R1	WELWYN HI MEG RX-1	RESISTOR	1,000 megohms		1%
R2	WELWYN HI MEG RX-1	RESISTOR	100 megohms		1%
R3	WELMET	RESISTOR	10 megohms		1 %
R4	ELECTRA RN65C 1004F	RESISTOR, MF	1 megohm	¼W	1%
R5		RESISTOR, CC	36 K	¼W	5%
R6		RESISTOR, CC	3.3 K	¼W	5%
R7		RESISTOR	100 K	¼W	5%
R8		RESISTOR, CC	51 K	¼W	5%
R9		RESISTOR, CC	51 K	¼W	5%
R10		RESISTOR, CC	1 K	¼W	5%
R11	ELECTRA RN65C 5112F	RESISTOR, MF	51.1 K	⅛W	1%
R12	BECKMAN HELITRIM 78PR500	TRIMPOT, CERMET	500 ohm	1W	
R13		RESISTOR, CC	2 K	¼W	5%
R14	ELECTRA RN65C 5112F	RESISTOR, MF	51.1 K	⅛W	1%
R15		RESISTOR, CC	10 K	¼W	5%
R16		RESISTOR, CC	2 K	¼W	5%
R17		RESISTOR, CC	2.2 K	¼W	5%
R18		RESISTOR, CC	150 ohm	¼W	5%
R19	BECKMAN HELITRIM 78PR10K	TRIMPOT, CERMET	10 K	1W	
R20		RESISTOR, CC	5.1 K	¼W	5%
R21					
R22		RESISTOR, CC	3.3 K	¼W	5%
R23		RESISTOR, CC	5.1 K	¼W	5%
R24	BECKMAN HELITRIM 78PR10K	TRIMPOT, CERMET	10 K	1W	

EAI—PARTS LIST

PARTS LIST NO.	TITLE
A04.01073 PL SHEET 2 OF ____	
L D NO	
PROJ NO	ENGINEER DATE / APPROVED DATE

REV	E O NO	DATE	APP'D	REV	E O NO	DATE	APP'D

REF DESIG	PART NO AND MANUFACTURER	DESCRIPTION
R25		RESISTOR, CC 3.9 K 2W 5%
R27		RESISTOR, CC 100 ohm ½W 5%
R28		RESISTOR, CC 1 K ohm ½W 5%
R29		RESISTOR, CC 100 ohm ½W 5%
R30		RESISTOR, CC 1 K ohm ½W 5%
R31		RESISTOR, CC 10 K ohm ½W 5%
R32		RESISTOR, CC 5.1K ohm ¼W 5%

EAI—PARTS LIST

PARTS LIST NO	TITLE
A04.01073 PL	
SHEET 3 OF ___	
L D NO	
PROJ NO.	ENGINEER DATE
	APPROVED DATE

REV	E O NO	DATE	APP D	REV	E O NO	DATE	APP D

REF DESIG	PART NO AND MANUFACTURER	DESCRIPTION
C2	SEC CK05CW220K	CAPACITOR, CER. 1 pf ±10% 200 VDC
C3	CENTRALAB CK502	CAPACITOR, CERAMIC .005 uf 50 V
C4	ELMENCO DM-10-050J	CAPACITOR, MICA 5 pf 500 V
C5	CENTRALAB DD102	CAPACITOR, CERAMIC .001 uf 1 KV
C6	SPRAGUE 5C7	CAPACITOR, CERAMIC 0.1 uf 25 VDC
C7	CENTRALAB CK103	CAPACITOR, CERAMIC .01 uf 50 VDC
C8	CENTRALAB UK-20-503	CAPACITOR, CERAMIC .05 uf 20 V
C9	SEC CK05CW101K	CAPACITOR, CER. 100 pf ±10% 200 V
C10	SEC CK05CW470K	CAPACITOR, CER. 47 pf ±10% 200 V
C11	SEC CK05CW221K	CAPACITOR, CER. 220 pf ±10% 200 V
C12	AEROVOX NO. BCD 20200	CAPACITOR, ELEC. 200 uf 20 VDC
C13	AEROVOX NO. BCD 20200	CAPACITOR, ELEC. 200 uf 20 VDC
C14	AEROVOX NO. BCD 20200	CAPACITOR, ELEC. 200 uf 20 VDC
C15	AEROVOX NO. BCD 20200	CAPACITOR, ELEC. 200 uf 20 VDC
C16	CENTRALAB CK103	CAPACITOR, CERAMIC .01 uf 50 VDC

EAI—PARTS LIST

PARTS LIST NO.	TITLE
A04.01073 PL	
SHEET 4 OF ____	
L D NO	
PROJ. NO.	ENGINEER DATE
	APPROVED DATE

REV	E O NO	DATE	APP'D	REV	E O NO	DATE	APP'D

REF DESIG	PART NO. AND MANUFACTURER	DESCRIPTION
CR1	MOTOROLA 1N3024B	DIODE
CR2	MOTOROLA 1N3024B	DIODE
CR3	MOTOROLA 1N751A	DIODE, ZENER
CR4	EAI # 90364	DIODE, REFERENCE 6.2V TEMP.COMP. .01%/°C
CR5	MOTOROLA MDA 942-2	RECTIFIER, BRIDGE
Q1	EAI # 90523	TRANSISTOR
Q3	MOTOROLA MPS6523	TRANSISTOR
Q4	FAIRCHILD 2N4355	TRANSISTOR
Q5	FAIRCHILD 2N4355	TRANSISTOR
Q6	FAIRCHILD 2N4355	TRANSISTOR
Q7	FAIRCHILD 2N4355	TRANSISTOR

EAI—PARTS LIST

PARTS LIST NO.	TITLE
A04.01073 PL	
SHEET 5 OF	
I. D. NO	

PROJ NO	ENGINEER	DATE	APPROVED	DATE

REV	E.O. NO	DATE	APP'D	REV.	E.O. NO	DATE	APP'D

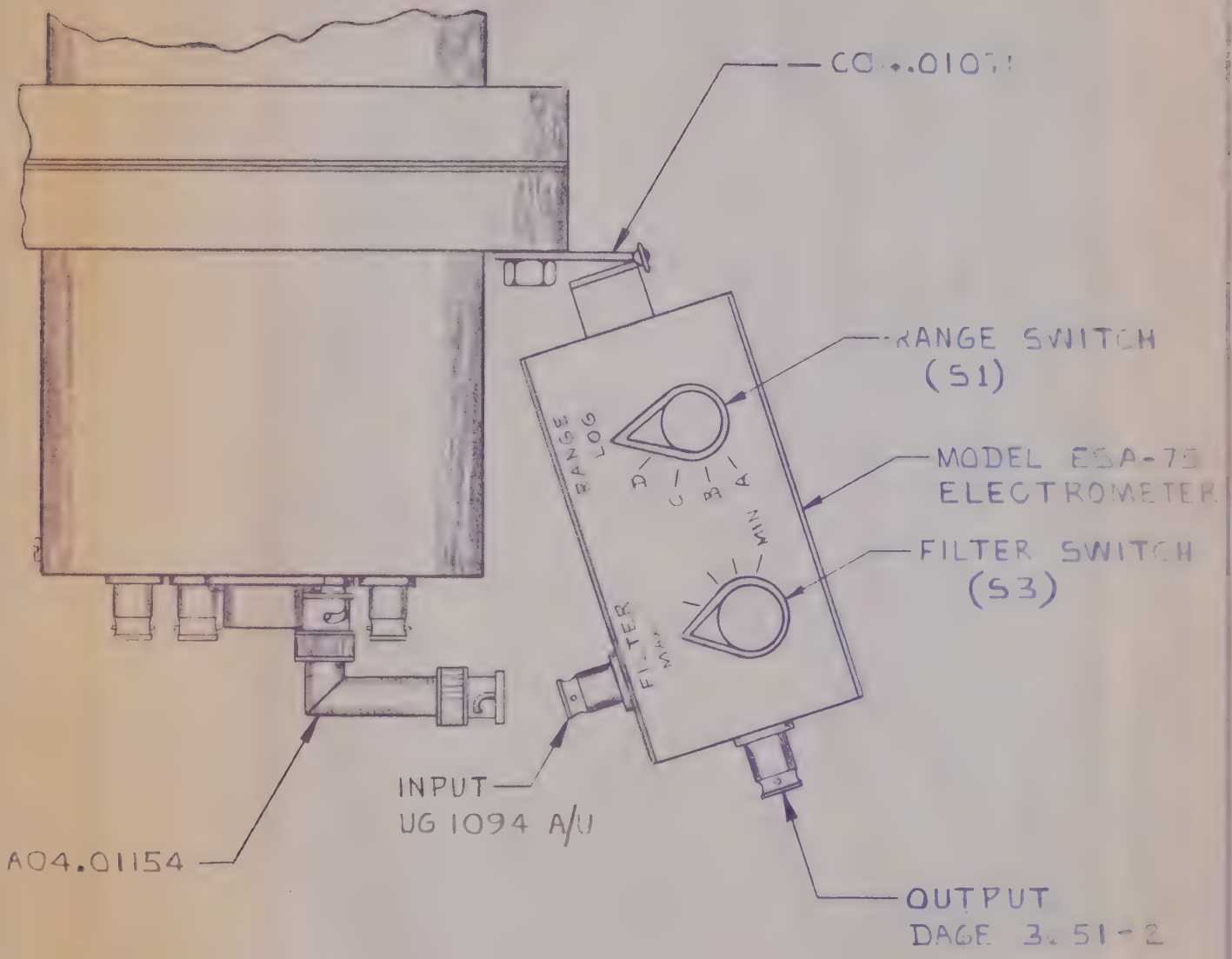
REF DESIG	PART NO AND MANUFACTURER	DESCRIPTION
A1	EAI 90722	AMPLIFIER
A2	EAI 90722	AMPLIFIER
S1	CENTRALAB P-505	SHAFT & INDEX, RANGE SWITCH
	CENTRALAB PS-22	SWITCH SECTION
	CENTRALAB PS-23	SWITCH SECTION
S2	C & K 7201	SWITCH, DPDT
S3	CENTRALAB P-505	SHAFT & INDEX, FILTER SWITCH
	CENTRALAB PS-23	SWITCH SECTION
J1	UG-1094/U	INPUT JACK
J2	CAGE 36651-2	OUTPUT JACK
T1	EAI 90037	TRANSFORMER
F1	LITTLEFUSE 1AG .062	FUSE, 1/16 AMP
DS1	INDUSTRIAL DEVICE 2220C-24	

EAI—PARTS LIST

PARTS LIST NO	TITLE	REV.	E.O NO	DATE	APP'D	REV	E O NO	DATE	APP'D
A04.01073 PL SHEET 6 OF 6									
L D NO									
PROJ NO	ENGINEER DATE	APPROVED DATE							

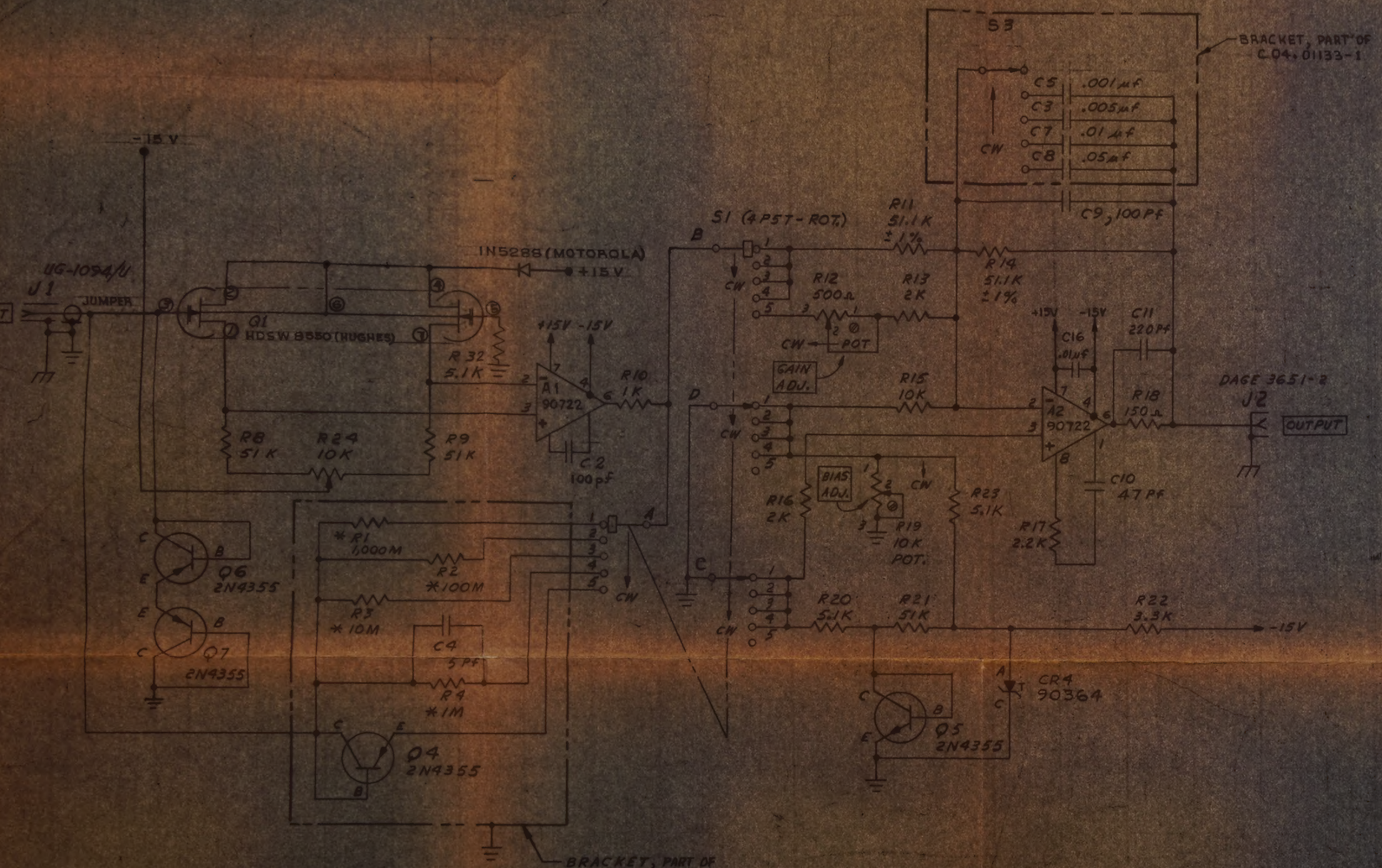
REF DESIG	PART NO AND MANUFACTURER	DESCRIPTION
		MISCELLANEOUS PARTS
P1	BELDEN 17106B	LAMP CORD, TWO-PRONG
		[illegible] (1 per unit)
	H.H. SMITH 2172	GROMMET, RUBBER (1 per unit)
	I.E.R.C.NO. TXBE-032-031B	HEATSINK (2 per unit)
	SEALECTRO FT-SM-51-TUR-C2	FEEDTHRU (1 per unit)
	SEALECTRO RST-250SL	STANDOFF (7 per unit)
	USECO 2062-B	TERMINALS (2 per unit)
	USECO 1280-B	TERMINALS (21 per unit)
	SMITH 8323	STANDOFF (6 per unit)
	HEYMAN MFG. No. SE-250-2	BUS ENG, SNAP, NYLON (2 per unit)
	RAYTHEON DS70-4-16	KNOBS, MATTE FINISH (2 per unit)
	CINCH 8-ICS	IC SOCKET

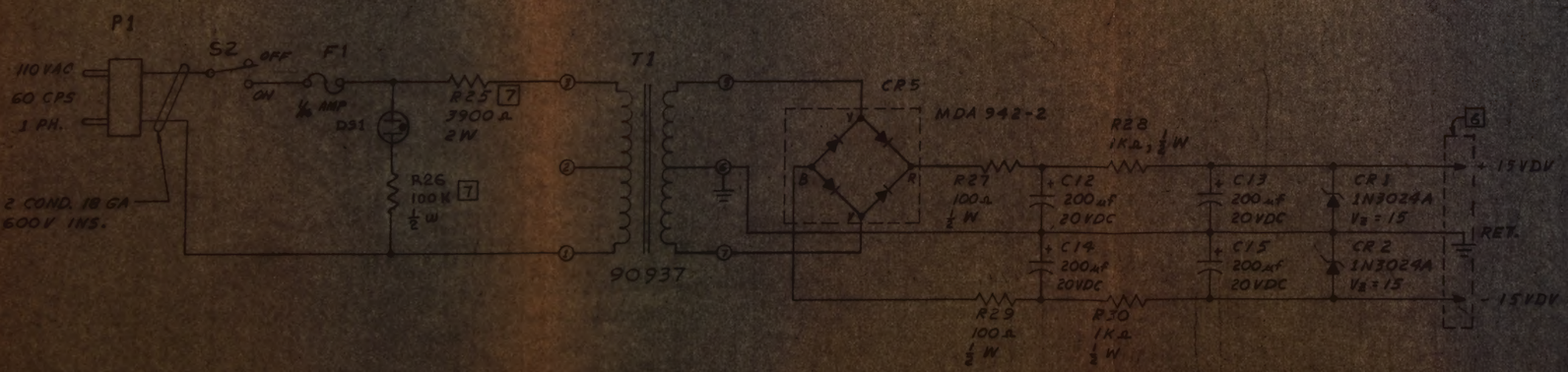
REVISION	
SYM	DESCRIPTION
2	REDRAWN



UNLESS OTHERWISE SPECIFIED			
DIMENSIONS ARE IN INCHES TOLERANCES ON DIMENSIONS DECIMAL ANGULAR 2 PLACE ± .02 ± 1 3 PLACE ± .005 4 PLACE ± .0005	DR CHK ENGR APPD APPD	EAI — ELECTRONIC ASSOCIATES PALO ALTO, CALIFORNIA	
MATERIAL	NEXT ASSY	CODE IDENT NO	SIZE A 04.01135
	USED ON LD 04.01074		

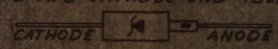
REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
3	REVISED PER E.O. Nº 00356		
4	REVISED PER E.O. Nº 00432		
5	REVISED PER E.O. Nº 00560	12/1/66	
6	REV PER MARKED PRINT IN RECORD FILE	4/6/67	
7	D-04.01075-05 WAS D-04.01075	6-15-70	
8	ZONE B2: ADD R26	6-19-70	





NOTES:

1. ⏚ THIS SYMBOL INDICATES CHASSIS GROUND
2. ⊥ THIS SYMBOL INDICATES CIRCUIT BOARD GROUND WHICH TERMINATES AT CHASSIS ONLY AT ONE POINT — J1 INPUT CONNECTOR
3. * THESE RESISTORS ARE SELECTED FOR RANGES AS REQUIRED BY CUSTOMER
4. ALL RESISTORS ARE ±5% TOL. ¼W UNLESS OTHERWISE SPECIFIED.
5. CR1 & CR2 CATHODE END IDENTIFIED PER FOLLOWING:



6. WHEN POWER SUPPLY IS NOT AN INTEGRAL PART OF AMPLIFIER A CONNECTOR INTERFACE SHALL BE USED. CONNECTOR IDENTITY "J4" AND WIRED WITH +15VDC AT J4 PIN 2, -15VDC AT J4 PIN 1 AND RETURN (RET.) ON J4 PIN 3.
7. FOR 220VAC OPERATION, R25 MUST BE CHANGED TO 13.6 KΩ @ 4W; AND R26 TO 200K
8. GROUND SHAFT MECHANISM OF SWITCH S1 & S3J USE LUG WIRED TO CHASSIS AT SOME CONVENIENT TIE POINT (GND)

ITEM NO.	QTY REQD	PART OR IDENTIFYING NO.	MATERIAL SIZE, DESCRIPTION & SPECIFICATION

LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DIMENSIONS
DECIMAL ANGULAR
2 PLACE ± .02 ±1°
3 PLACE ± .005
4 PLACE ± .0005
MATERIAL
FINISH

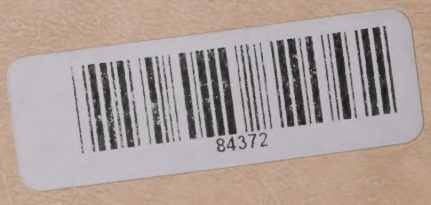
DR L.SAENZ 12/1/67
CHK A.R.Clements DEC. 11 1967
ENGR
APPD
APPD

EAI ELECTRONIC ASSOCIATES, INC. PALO ALTO, CALIFORNIA

SCHEMATIC
ELECTROMETER
ESA MOD. 75

NEXT ASSY PL-04.01073
USED ON ESA-75

CODE IDENT NO. —
SIZE D
04.01075-05
REV 8
SCALE NONE
PROJ. NO.
SHEET 1 OF 1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